

# **Enhanced and Synthetic Vision for Remotely Piloted Vehicles**

VPS Naidu, Narayana Rao P. and Girija G  
MSDF Lab, FMCD  
CSIR - National Aerospace Laboratories  
Bangalore-17, India  
vpsnaidu@gmail.com

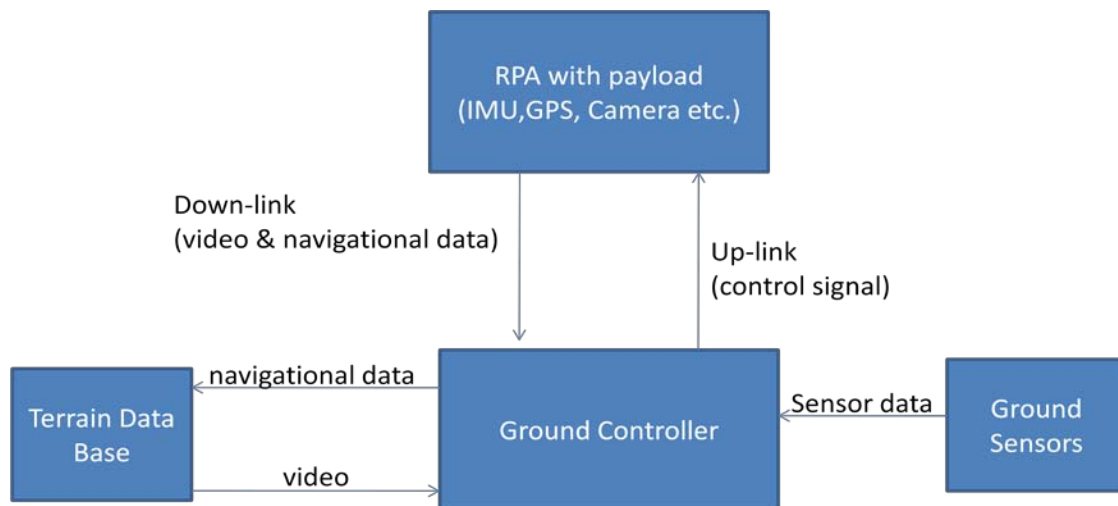
Over the past decade, remotely piloted aircraft (RPAs) and unmanned aerial vehicles (UAVs) have proven their worth in operations around the world. Technological advances and ever-changing global situations make unmanned systems more attractive and feasible now than ever before. New sensors available in smaller sizes and lighter weights provide great capability per unit of weight. The advancement in data link technology provides high bandwidth connectivity for vehicle command and control and data transfer. Advances in microprocessor technology, software development, inertial navigation systems (INS), and global positioning systems (GPS) enable robust autonomous flight control systems and onboard processing of sensor data. Further, new composite materials and improved propulsion systems contribute to reduction in weight and fuel efficiency. Net-centric operations enable RPAs, UAVs, and networked ground systems to conduct missions more effectively and increase the effectiveness of manned and space platforms. In net-centric approach, command and control of unmanned vehicles is conducted remotely via communication links. Additionally, it is possible to separate the sensor information from aircraft command links so that the sensor data can be supplied directly to distributed analysts, decision-makers, and global customers.

Like manned aircraft, unmanned aircraft are susceptible to adverse weather conditions. The deteriorated weather conditions make it difficult to operate the RPAs in the same manner and rate as in visual meteorological conditions. It is necessary that the UAS knows the landing environment with sufficient detail to land safely. Enhanced and Synthetic Vision (ESV) could provide the ability to display transient elements in a real time scene and highlight the potential landing hazards. The real time imagery analysis can be used to detect anomalous components in a scene. Highway in the sky (HITS) visualization scheme can be used to safely design approach to landing procedures in open airspace areas. Airborne terrain database correlated with inertial and GPS data can provide a high level of autonomous terrain awareness in addition to the mission controller display.

This paper describes the work carried out at FMCD, NAL towards realizing an ESV system (ESVS) for improving the situational awareness of the Operator at the Ground Control station.

The block diagram of the proposed ESV system is shown in Fig.1. Remote piloted aircraft (RPA) with payload sends the navigational data and video data of the scene to the ground control station (GCS) which also receives data from the ground based tracking sensors. The navigation data is used to pick up the appropriate synthetic data from the terrain data base which

is sent to the ground control station as a video stream. All the information is appropriately fused and presented on the display.



**Figure 1 : Information Flow Diagram of Enhanced and Synthetic Vision for UAS**

RPA would have its own attitude heading reference unit (AHRS), inertial navigation system (INS) and GPS etc. to get position and attitude. The payload could be electro optical systems or scanners, infrared systems and radars which can penetrate through bad weather. *The* ground control station (GCS) has flight display, navigation system, system health monitoring, data processing, graphical images and position mapping and secure communication system. GCS also controls the payload, launch and recovery of UAS. Data link provides vital communication between the ground station and airborne system.

Data and Information Fusion is the core of the ESVS. Navigation data obtained from INS and GPS is fused with ground based tracking sensors to improve the position accuracy of the RPA. The visual information (enhanced vision) from the RPA payload sensors is augmented with computer generated imagery (synthetic vision) to improve the situational awareness during adverse weather conditions.

An Enhanced Vision System (EVS) prototype unit has been developed and tested by mounting it on a ground vehicle. Fig-2a shows the EVS prototype consisting of EO and IR sensors mounted on the test vehicle and Fig-2b shows the captured images from EO and IR sensors as well as the fused image obtained from combining the two images.



Fig-2a. EVS prototype with stand mounted on test vehicle    b). EO, IR and fused images

Future work in ESVS for UAV operator will require combining terrain data and weather information with data from video or Infrared camera in real time and presented to the operators as an image display together with threat locations, expected locations of targets, landmarks, emergency airfields etc. However, to ascertain that the synthetic vision system is beneficial for UAV applications, the human factors issues are to be evaluated in simulations and flight test evaluations to arrive at the best manner of combining the SV and the live camera data and presenting the same to the operator.

## References

1. G. Natarajan, "Ground Control Station for Unmanned Air Vehicle", Defense Science journal, Vol.51, No.3, 2001.
2. VPS Naidu and J.R. Raol, "Pixel-Level Image Fusion using Wavelets and Principal Component Analysis – A Comparative Analysis" Defense Science Journal, Vol.58, No.3, pp.338-352, May 2008.
3. Jochum Tadema, Joris Koeners and Eric Theunissen, "Synthetic Vision to Augment Sensor based Vision for Remotely Piloted Vehicles", Proc. of SPIE, Vol.6226, 2006.
4. Simonoff, "Remotely Piloted Vehicle Control and Interface System", US patent, US000001469H, 1995.
5. The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision, 2005, <http://digitalcommons.unl.edu/usafresearch/1>
6. VPS Naidu, Narayana Rao P., Sudesh K. Kashyap, Santhakumat N. and Girija G., "Experimental Study with enhanced Vision System Prototype Unit", ICIIP 2011, Nov.3-5, 2011.
7. Philippe Roy, "Enhanced Synthetic Vision Systems and Multi-Sensor Data Fusion to Improve Operational Capabilities of small Tactical UAV", AIAA Conference and Exhibit, 7-10 May 2007, Rohnert Park, California, AIAA paper No. 2007-2952

### Authors profile:



**VPS Naidu** obtained M.E in Medical electronics from Anna University Chennai and PhD from University of Mysore, Mysore in board of studies, Electronics. He is working at Multi sensor data fusion lab, CSIR-National Aerospace Laboratories, Bangalore as scientist since December 2001. His research areas of interest are: Multi Sensor Data Fusion and Enhanced Flight Vision System. He received four awards for his research contribution.



**Mr. Narayana Rao P.** is currently working as a Project Engineer at Flight Mechanics and Control Division, National Aerospace Laboratories. He received B.E degree in Electrical and Electronics Engineering from Andhra University, Visakhapatnam. He was a research student with Indian Institute of Science, Bangalore. His research interests include Aircraft Control and Simulation, Aircraft Systems, Estimation, Data Fusion and Artificial Intelligence.



**Dr. (Mrs) Girija Gopalratnam** obtained her Ph.D. degree from Bangalore University in the year 1996. She holds Masters Degree and B.Sc (Hons) in Physics. She is working as a Scientist at the National Aerospace Laboratories since 1981. She received NAL Outstanding Performance award for Research in the year 1996. She has led teams which have received NAL Outstanding Performance award for Design, Development and Project execution in the areas of Parameter estimation and Multi Sensor Data Fusion. She has over 60 research publications in peer reviewed journals and conferences. She is a co-author of the book “Modeling and parameter estimation of dynamic systems” published by IEE Control Engineering Series. She is a Life member of the Aeronautical Society of India. She is currently Deputy Head of FMCD, NAL and Group Head, Multi Sensor Data Fusion Group at NAL. Her R&D interests include Multi sensor data fusion, Information fusion, Multi sensor multi target tracking, Modelling and Parameter Estimation of dynamical systems, Fusion for enhanced synthetic vision, Bayesian networks and Fuzzy logic.